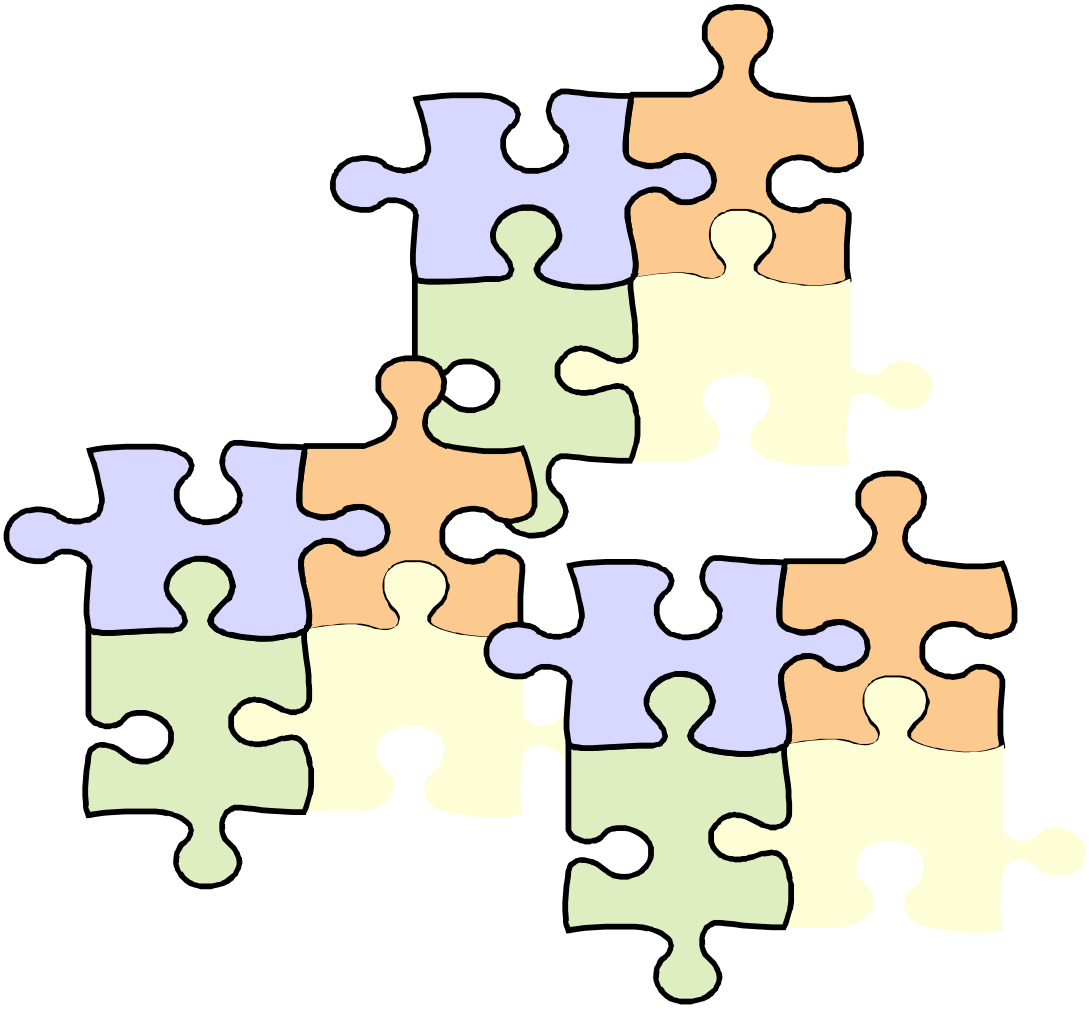
Single Subject Matter Standards:
Science

February 2003

California Commission on Teacher Credentialing



Single Subject Matter Standards of Quality and Effectiveness for Programs in Science

California Commission on Teacher Credentialing

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Standards Common to All

Standard 1: Program Philosophy and Purpose

The subject matter preparation program is based on an explicit statement of program philosophy that expresses its purpose, design, and desired outcomes in relation to the Standards of Quality and Effectiveness for Single Subject Teaching Credential Programs. The program provides the coursework and field experiences necessary to teach the specified subject to all of California's diverse public school population. Subject matter preparation in the program for prospective teachers is academically rigorous and intellectually stimulating. The program curriculum reflects and builds on the State-adopted *Academic Content Standards for K-12 Students* and *Curriculum Frameworks for California Public Schools.* The program is designed to establish a strong foundation in and understanding of subject matter knowledge for prospective teachers that provides a basis for continued development during each teacher's professional career. The sponsoring institution assigns high priority to and appropriately supports the program as an essential part of its mission.

Required Elements

1.1 The program philosophy, design, and intended outcomes are consistent with the content of the State-adopted Academic Content Standards for K-12 students and Curriculum Frameworks for California public schools.

1.2 The statement of program philosophy shows a clear understanding of the preparation that prospective teachers need in order to be effective in delivering academic content to all students in California schools.

1.3 The program provides prospective teachers with the opportunity to learn and apply significant ideas, structures, methods and core concepts in the specified subject discipline(s) that underlies the 6-12 curriculum.

1.4 The program prepares prospective single-subject teachers to analyze complex discipline-based issues; synthesize information from multiple sources and perspectives; communicate skillfully in oral and written forms; and use appropriate technologies.

1.5 Program outcomes are defined clearly and assessments of prospective teachers and program reviews are appropriately aligned.

1.6 The institution conducts periodic review of the program philosophy, goals, design, and outcomes consistent with the following: campus program assessment timelines, procedures, and policies; ongoing research and thinking in the discipline; nationally accepted content standards and recommendations; and the changing needs of public schools in California.

Standard 2: Diversity and Equity

The subject matter program provides equitable opportunities to learn for all prospective teachers by utilizing instructional, advisement and curricular practices that insure equal access to program academic content and knowledge of career options. Included in the program are the essential understandings, knowledge and appreciation of the perspectives and contributions by and about diverse groups in the discipline.

Required Elements:

2.1 In accordance with the Education Code Chapter 587, Statutes of 1999, (See Appendix A), human differences and similarities to be examined in the program include, but are not limited to those of sex, race, ethnicity, socio-economic status, religion, sexual orientation, and exceptionality. The program may also include study of other human similarities and differences.

2.2 The institution recruits and provides information and advice to men and women prospective teachers from diverse backgrounds on requirements for admission to and completion of subject matter programs.

2.3 The curriculum in the Subject Matter Program reflects the perspectives and contributions of diverse groups from a variety of cultures to the disciplines of study.

2.4 In the subject matter program, classroom practices and instructional materials are designed to provide equitable access to the academic content of the program to prospective teachers from all backgrounds.

2.5 The subject matter program incorporates a wide variety of pedagogical and instructional approaches to academic learning suitable to a diverse population of prospective teachers. Instructional practices and materials used in the program support equitable access for all prospective teachers and take into account current knowledge of cognition and human learning theory.

Standard 3: Technology

The study and application of current and emerging technologies, with a focus on those used in K-12 schools, for gathering, analyzing, managing, processing, and presenting information is an integral component of each prospective teacher's program study. Prospective teachers are introduced to legal, ethical, and social issues related to technology. The program prepares prospective teachers to meet the current technology requirements for admission to an approved California professional teacher preparation program.

Required Elements**:**

3.1 The institution provides prospective teachers in the subject matter program access to a wide array of current technology resources. The program faculty selects these technologies on the basis of their effective and appropriate uses in the disciplines of the subject matter program

3.2 Prospective teachers demonstrate information processing competency, including but not limited to the use of appropriate technologies and tools for research, problem solving, data acquisition and analysis, communications, and presentation.

3.3 In the program, prospective teachers use current and emerging technologies relevant to the disciplines of study to enhance their subject matter knowledge and understanding.

Standard 4: Literacy

The program of subject matter preparation for prospective Single Subject teachers develops skills in literacy and academic discourse in the academic disciplines of study. Coursework and field experiences in the program include reflective and analytic instructional activities that specifically address the use of language, content and discourse to extend meaning and knowledge about ideas and experiences in the fields or discipline of the subject matter.

Required Elements**:**

4.1 The program develops prospective teachers' abilities to use academic language, content, and disciplinary thinking in purposeful ways to analyze, synthesize and evaluate experiences and enhance understanding in the discipline.

4.2 The program prepares prospective teachers to understand and use appropriately academic and technical terminology and the research conventions of the disciplines of the subject matter.

4.3 The program provides prospective teachers with opportunities to learn and demonstrate competence in reading, writing, listening, speaking, communicating and reasoning in their fields or discipline of the subject matter.

Standard 5: Varied Teaching Strategies

In the program, prospective Single Subject teachers participate in a variety of learning experiences that model effective curriculum practices, instructional strategies and assessments that prospective teachers will be expected to use in their own classrooms.

Required Elements**:**

5.1 Program faculty include in their instruction a variety of curriculum design, classroom organizational strategies, activities, materials, and field experiences incorporating observing, recording, analyzing and interpreting content as appropriate to the discipline.

5.2 Program faculty employ a variety of interactive engaging teaching styles that develop and reinforce skills and concepts through open-ended activities such as direct instruction, discourse, demonstrations, individual and cooperative learning explorations, peer instruction, and student-centered discussion.

5.3 Faculty development programs provide tangible support for subject matter faculty to explore and use exemplary and innovative curriculum practices.

5.4 Program faculty use varied and innovative teaching strategies, which provide opportunities for prospective teachers to learn how content is conceived and organized for instruction in a way that fosters conceptual understanding as well as procedural knowledge.

5.5 Program coursework and fieldwork include the examination and use of various kinds of technology that are appropriate to the subject matter discipline.

Standard 6: Early Field Experiences

The program provides prospective Single Subject teachers with planned, structured field experiences in departmentalized classrooms beginning as early as possible in the subject matter program. These classroom experiences are linked to program coursework and give a breadth of experiences across grade levels and with diverse populations. The early field experience program is planned collaboratively by subject matter faculty, teacher education faculty and representatives from school districts. The institution cooperates with school districts in selecting schools and classrooms for introductory classroom experiences. The program includes a clear process for documenting each prospective teacher's observations and experiences.

Required Elements**:**

6.1 Introductory experiences shall include one or more of the following activities: planned observations, instruction or tutoring experiences, and other school based observations or activities that are appropriate for undergraduate students in a subject matter preparation program.

6.2 Prospective teachers' early field experiences are substantively linked to the content of coursework in the program.

6.3 Fieldwork experiences for all prospective teachers include significant interactions with K-12 students from diverse populations represented in California public schools and cooperation with at least one carefully selected teacher certificated in the discipline of study.

6.4 Prospective teachers will have opportunities to reflect on and analyze their early field experiences in relation to course content. These opportunities may include field experience journals, portfolios, and discussions in the subject matter courses, among others.

6.5 Each prospective teacher is primarily responsible for documenting early field experiences. Documentation is reviewed as part of the program requirements.

Standard 7: Assessment of Subject Matter Competence

The program uses formative and summative multiple measures to assess the subject matter competence of each candidate. The scope and content of each candidate's assessment is consistent with the content of the subject matter requirements of the program and with institutional standards for program completion.

Required Elements**:**

7.1 Assessment within the program includes multiple measures such as student performances, presentations, research projects, portfolios, field experience journals, observations, and interviews as well as oral and written examinations based on criteria established by the institution.

7.2 The scope and content of each assessment is congruent with the specifications for the subject matter knowledge and competence as indicated in the content domains of the Commission-adopted subject matter requirement.

7.3 End-of-program summative assessment of subject matter competence includes a defined process that incorporates multiple measures for evaluation of performance.

7.4 Assessment scope, process, and criteria are clearly delineated and made available to students when they begin the program.

7.5 Program faculty regularly evaluate the quality, fairness, and effectiveness of the assessment process, including its consistency with program requirements.

7.6 The institution that sponsors the program determines, establishes and implements a standard of minimum scholarship (such as overall GPA, minimum course grade or other assessments) of program completion for prospective single subject teachers.

Standard 8: Advisement and Support

The subject matter program includes a system for identifying, advising and retaining prospective Single Subject teachers. This system will comprehensively address the distinct needs and interests of a range of prospective teachers, including resident prospective students, early deciders entering blended programs, groups underrepresented among current teachers, prospective teachers who transfer to the institution, and prospective teachers in career transition

Required Elements:

8.1 The institution will develop and implement processes for identifying prospective Single Subject teachers and advising them about all program requirements and career options.

8.2 Advisement services will provide prospective teachers with information about their academic progress, including transfer agreements and alternative paths to a teaching credential, and describe the specific qualifications needed for each type of credential, including the teaching assignments it authorizes.

8.3 The subject matter program facilitates the transfer of prospective teachers between post-secondary institutions, including community colleges, through effective outreach and advising and the articulation of courses and requirements. The program sponsor works cooperatively with community colleges to ensure that subject matter coursework at feeder campuses is aligned with the relevant portions of the *State-adopted Academic Content Standards for K-12 Students in California Public Schools*.

8.4 The institution establishes clear and reasonable criteria and allocates sufficient time and personnel resources to enable qualified personnel to evaluate prospective teachers' previous coursework and/or fieldwork for meeting subject matter requirements.

Standard 9: Program Review and Evaluation

The institution implements a comprehensive, ongoing system for periodic review of and improvement to the subject matter program. The ongoing system of review and improvement involves university faculty, community college faculty, student candidates and appropriate public schools personnel involved in beginning teacher preparation and induction. Periodic reviews shall be conducted at intervals not exceeding 5 years.

Required Elements:

9.1 Each periodic review includes an examination of program goals, design, curriculum, requirements, student success, technology uses, advising services, assessment procedures and program outcomes for prospective teachers.

9.2 Each program review examines the quality and effectiveness of collaborative partnerships with secondary schools and community colleges.

9.3 The program uses appropriate methods to collect data to assess the subject matter program's strengths, weaknesses and areas that need improvement. Participants in the review include faculty members, current students, recent graduates, education faculty, employers, and appropriate community college and public school personnel.

9.4 Program improvements are based on the results of periodic reviews, the inclusion and implications of new knowledge about the subject(s) of study, the identified needs of program students and school districts in the region, and curriculum policies of the State of California.

Standard 10: Coordination

One or more faculty responsible for program planning, implementation and review coordinate the Single Subject Matter Preparation Program. The program sponsor allocates resources to support effective coordination and implementation of all aspects of the program. The coordinator(s) foster and facilitate ongoing collaboration among academic program faculty, local school personnel, local community colleges and the professional education faculty.

Required Elements:

10.1 A program coordinator will be designated from among the academic program faculty.

10.2 The program coordinator provides opportunities for collaboration by faculty, students, and appropriate public school personnel in the design and development of and revisions to the program, and communicates program goals to the campus community, other academic partners, school districts and the public.

10.3 The institution allocates sufficient time and resources for faculty coordination and staff support for development, implementation and revision of all aspects of the program.

10.4 The program provides opportunities for collaboration on curriculum development among program faculty.

10.5 University and program faculty cooperate with community colleges to coordinate courses and articulate course requirements for prospective teachers to facilitate transfer to a baccalaureate degree-granting institution.

Standards for Science

Standard 11: The Vision for Science

The institution articulates a philosophical vision of science and the education of prospective science teachers. Each program references the current Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) as part of its vision statement.

Required Elements

11.1 The program includes a code of ethics that can be applied to the practice of science.

11.2 The program examines ethical, moral, social, and cultural implications of significant issues and ideas in science and technology.

11.3 The program explores practical solutions to challenging important and relevant problems.

Standard 12: General Academic Quality

The program is academically rigorous and intellectually stimulating. It provides opportunities for students to experience and practice analyzing complex situations to make informed decisions and to participate in scientific problem solving. In the program, each prospective teacher develops effective written and oral communication skills with a focus on concepts and methodologies that comprise academic discourse in science.

Required Elements

12.1 The program requires sufficient practice in written and oral communication skills that enable prospective teachers to express scientific ideas, concepts, and methods accurately.

12.2 The program promotes the use of quantitative reasoning and encourages prospective teachers to analyze complex situations, make informed decisions, and participate in scientific problem solving.

12.3 The program regularly requires prospective teachers to participate in scientific investigations.

12.4 The program allows prospective teachers to gain experience in critically analyzing and reviewing scientific writings and research.

12.5 The program provides opportunities for prospective teachers to examine conceptual and physical models and their evolution over time.

Standard 13: Integrated Study of Science

The program reflects science as an integrated entity and examines interrelationships among the disciplines, and variations in the structures, content, and methods of inquiry in the disciplines are studied. Each prospective single subject teacher gains an understanding of how the conceptual foundations of the scientific disciplines are related to each other.

Required Elements

13.1 Each integrative study component develops the prospective single subject teacher's understanding of how the conceptual foundations of the scientific disciplines are related to each other.

13.2 Each integrative study component provides opportunities for prospective teachers to examine the interconnections between different fields of science.

13.3 The integrative study component(s) of the program require that prospective teacher use higher-level thinking skills while involved in coursework and research in each science discipline.

13.4 Faculty teaching in the program and prospective teachers in various disciplines of science meet regularly to exchange ideas and perspectives.

13.5 The program includes courses and/or projects that integrate science as a whole.

Standard 14: Breadth of Study in Science

The science program is organized to provide prospective teachers a sufficiently broad understanding of science so that, as future literate science teachers, they have the necessary knowledge, skills, and abilities to develop scientific literacy among their students. A breadth of study provides familiarity with the nature of science and major ideas foundational to all the sciences and provides a basis for prospective teachers to engage in further studies of a scientific discipline. The program is aligned with the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998).

Required Elements

14.1 The program encompasses the general science specifications for subject matter knowledge and competence on pages 21 through 31, which includes the following general areas of study aligned with the K-12 student academic content standards.

14.2 The program addresses the subject matter skills and abilities applicable to the content domains in science listed below:

- A- Astronomy
- B- Dynamic Processes of the Earth (Geodynamics)
- C- Earth Resources
- D- Ecology
- E- Genetics/Evolution
- F- Molecular Biology and Biochemistry
- G- Cell and Organismal Biology
- H- Waves
- I- Forces and Motion
- J- Electricity and Magnetism
- K- Heat Transfer and Thermodynamics
- L- Structure and Properties of Matter

Standard 15: Depth of Study in a Concentration Area

Each candidate for the Single Subject Teaching Credential in Science must complete a subject matter program that includes Concentration 15A, 15B, 15C, or 15D. Concentration in the identified discipline prepares prospective teachers to teach a full range of courses authorized by the single subject credential authorization. Depth within a discipline is essential for teaching advanced and specialized courses.

Standard 15A: Depth of Study in Biological Sciences

The Concentration in Biological Sciences includes a depth of study of biology that is significantly greater than that required for a general understanding of science as described in Standard 14. The depth of study in Concentration 15A should provide conceptual foundations distributed across the discipline. Integral to the concentration are conceptual foundations that include cell biology and physiology, genetics, evolution, and ecology. Concentration 15A includes in-depth study and field/laboratory experiences in biology; achievement of an appropriate level of understanding in chemistry, mathematics and physics, use of methods employed by scientists in the generation knowledge; and application of biological sciences to technological and societal issues including ethical considerations. Candidates for the Science Credential with a Concentration in Biological Science will be able to teach a wide variety of biology courses in their teaching assignments. The program is aligned with the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998). The Concentration in Biological Sciences will prepare prospective teachers to teach the full range of biology courses authorized by this credential.

Required Elements

15A.1 Encompass the biological science requirements for subject matter knowledge and competence on pages 32 through 38, which are aligned with the K-12 student academic content standards.

15A.2 Encompass the subject matter skills and abilities applicable to the content domains in science as stated in the SMR Part II section on pages 58 to 63.

Standard 15B: Depth of Study in Chemistry

The Concentration in Chemistry includes a depth of study within chemistry significantly greater than that required for a general understanding of science as described in Standard 5. The depth of study should provide conceptual foundations that include atomic and molecular structure, chemical reactions, kinetic molecular theory, solution chemistry, chemical thermodynamics, organic chemistry and biochemistry, and nuclear processes. Concentration 15B include in-depth study and field/laboratory experiences in chemistry, achievement of an appropriate level of understanding in mathematics and physics, use of methods employed by scientists in the generation of scientific knowledge, and application of chemistry to technological and societal issues including ethical considerations. Candidates for the Science Credential with a Concentration in Chemistry will be able to teach a wide variety of chemistry courses in their teaching assignments. The program is aligned with the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998).

Required Elements

15B.1 Encompass the subject matter skills and abilities applicable to the content domains in science as stated in the SMR Part II section on pages 58 to 63.

15B.2 Include demonstration of mathematical skills and other scientific knowledge needs to complete studies that are required by advanced courses in chemistry.

15B.3 Encompass the chemistry specifications for subject matter knowledge and competence on pages 39 through 44 that are aligned with the K-12 student academic content standards.

Standard 15C: Depth of Study in Geosciences (Earth and Planetary Sciences)

The Concentration in Geosciences (Earth and Planetary Sciences) includes a depth of study greater than that required for a general understanding of science as described in Standard 14. The depth of study in Concentration 15C should provide conceptual foundations in the earth and planetary sciences and should provide conceptual foundations that include the Earth's place in the universe, planet Earth, energy in the Earth System, biochemical cycles, and California geology. Concentration 15C includes in-depth study and field/laboratory experiences in earth and planetary sciences, achievement of an appropriate level of understanding in mathematics, use of methods employed by scientists in the generation of scientific knowledge, and application of earth and planetary sciences to technological and societal issues including ethical consideration. Candidates for the Science Credential with a Concentration in Geosciences will be able to teach a wide variety of courses in their teaching assignments. The program is aligned with the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998).

Required Elements

15C.1 Encompass the earth and planetary sciences specifications for subject matter knowledge and competence on pages 45 through 52 that are aligned with the K-12 student academic content standards.

15C.2 Encompass the subject matter skills and abilities applicable to the content domains in science as stated in the SMR Part II section on pages 58 to 63.

15C.3 Include demonstration of mathematical skills needed to complete studies that are required by advanced courses in the earth and planetary sciences.

Standard 15D: Depth of Study in Physics

The Concentration in Physics includes a depth of study of physics significantly greater than that required for a general understanding of science as described in Standard 14. The depth of study in Concentration 15D should provide conceptual foundations in physics and should provide conceptual foundations distributed across the discipline of physics. Integral to the concentration are conceptual foundations that include motion and forces, conservation of energy and momentum, heat and thermodynamics, waves, electromagnetism, and quantum mechanics and the standard model of particles. Concentration 15D include in-depth study and laboratory experiences in physics, achievement of an appropriate level of understanding in mathematics and use of methods employed by scientists in the generation of scientific knowledge. Candidates for the Science Credential with a Concentration in Physics will be able to teach a wide variety of physics courses in their teaching assignments. The program is aligned with the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998)

Required Elements

15D.1 Encompass the physics specifications for subject matter knowledge and competence on pages 53 through 57 that are aligned with the K-12 student academic content standards.

15D.2 Encompass the subject matter skills and abilities applicable to the content domains in science in the SMR Part II section on pages 58 to 63.

15D.3 Include demonstration of mathematical skills needed to complete studies that are required by advanced courses in physics.

Standard 16: Laboratory and Field Experiences

Laboratory and field experiences constitute a significant portion of coursework in a program that includes open-ended, problem solving experiences. Prospective teachers have the opportunity to design a variety of laboratory experiments. Data are collected, analyzed, and processed using statistical analysis and current technology (where appropriate).

Required Elements

16.1 The program includes required laboratory components in no less than one-third of its courses.

16.2 The program includes periodic open-ended, problem solving experiences in its coursework.

16.3 The program requires prospective teachers to organize, interpret, and communicate observation data collected during laboratory or field experiences using statistical analysis when appropriate.

16.4 The program requires prospective teachers to design and evaluate laboratory experiments and/or fieldwork.

16.5 The program involves prospective teachers in research and collection of data that requires utilization of current technology.

Standard 17: Safety Procedures

The program instructs prospective teachers in proper safety procedures prior to laboratory and field experiences. This includes instruction in emergency procedures and proper storage, handling and disposal of chemicals and equipment. The program provides facilities equipped with necessary safety devices and appropriate storage areas. When the program provides experiences with live organisms, they are observed, captured, and cared for both ethically and lawfully.

Required Elements

17.1 The program instructs prospective teachers in proper safety procedures (safe uses of chemicals, specimens, and specialty equipment) prior to laboratory and field experiences, and implements current safety guidelines and regulations.

17.2 The program provides facilities that are equipped with appropriate safety devices.

17.3 The program provides instruction in, and demonstrates emergency procedures and proper storage, handling, and disposal of chemicals, specimen, and equipment.

General Science Subject Matter Requirements

Part I: Content Domains for Subject Matter Understanding and Skill in General Science

Domain 1. Astronomy

Candidates demonstrate an understanding of the foundations of the astronomy contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of astronomy and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that knowledge of the structure and composition of the universe can be learned from studying stars and galaxies and their evolution. They recognize that objects in the sky move in regular and predictable patterns. Candidates explain how and why the moon's appearance changes during the four-week lunar cycle. They understand how telescopes magnify the appearance of distant objects in the sky, including the moon and the planets. They realize that the solar system consists of planets and other bodies that orbit the sun in predictable paths.

1.1 Astronomy

a. Describe the chemical composition and physical structure of the universe
b. Describe the structure of the solar system and its place in the Milky Way galaxy
c. Distinguish between stars and planets
d. Recognize that stars vary in color, size, and luminosity
e. Describe a simple model of how fusion in stars produces heavier elements and results in the production of energy, including light
f. Describe the regular and predictable patterns of stars and planets in time and location
g. Explain and predict changes in the moon's appearance (phases)
h. Describe the use of astronomical instruments in collecting data, and use astronomical units and light years to describe distances

(Science Content Standards for California Public Schools, Grades 3:4a-e; Grade 5: 5a-c; Grade 6: 7a; Grade 7: 6d, 7a; Grade 8:4a-e; Grades 9-12, Earth Sciences: 1a, 1e, 1g, 2a, 2c, 2e-f)

Domain 2. Dynamic Processes of the Earth (Geodynamics)

Candidates demonstrate an understanding of the foundations of the geodynamics contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of geodynamics and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that Earth's features can be explained by a variety of dynamic processes that have occurred in the past and continue to occur. They understand that

plate tectonics account for most of the important features of Earth's surface and major geologic events. Candidates explain how surficial processes and agents such as waves, wind, water, and ice are slowly modifying Earth's land surface. They understand how weathering, transport, and deposition of sediment are related to this reshaping. Candidates are familiar with evidence from rocks that allows us to understand geologic history and the evolution of life on Earth. They can use observed properties of rocks and minerals to determine their processes of formation. Candidates understand that most of the energy on the Earth comes from the sun. They know that energy from the sun heats Earth unevenly, causing air movements that result in changing weather patterns. They use their understanding of heat to explain the many phenomena on Earth's surface that are affected by the transfer of energy through radiation and convection.

2.1 Tectonic Processes and Features

a. Diagram the features that provide evidence for plate tectonics
b. Summarize the thermal processes driving plate movement
c. Explain how density and buoyancy are related to plate tectonics
d. Describe types of plate boundaries
e. Relate the causes of volcanoes, earthquakes, and earth resources to tectonic processes
f. Summarize earthquake processes in terms of epicenter, focal mechanism, distance, and materials, and the role various factors play in the amount of damage caused by an earthquake

(Science Content Standards for California Public Schools, Grade 6: 1a-g; Grade 8: 4a-e; Grades 9-12, Earth Sciences: 1e, 1g, 2c, 3b, 3d)

2.2 Rock Formation

a. Diagram and explain the rock cycle
b. Describe relative and absolute dating techniques, including how half-lives are used in radiometric dating
c. Compare uniformitarianism and catastrophism

(Science Content Standards for California Public Schools, Grade 4: 4a; Grade 7: 3c, 4a–e; Grades 9-12, Chemistry: 11f)

2.3 Shaping Earth's Surface: Surficial Processes and Features

a. Describe the dynamic processes of erosion, deposition, and transport
b. Describe coastal processes including beach erosion and natural hazards
c. Describe the effects of natural hazards, including earthquakes, volcanic eruptions, landslides, and floods, on natural and human-made habitats and environmental and human responses to those events

(Science Content Standards for California Public Schools, Grade 4: 5c; Grade 6: 1e, 1f, 2a–d)

2.4 Energy in the Earth System

a. Diagram the water cycle and describe interrelationships of surface and sub-surface reservoirs
b. Explain daily and seasonal changes in the sky (i.e., the sun's position and the intensity and duration of sunlight)
c. Analyze the uneven heating of Earth by the sun
d. Discuss the effects of air movements on weather
e. Describe the energy transfer processes of convection, conduction, and radiation in relation to the atmosphere/ocean and Earth's interior structure
f. Interpret weather maps to predict weather patterns

(Science Content Standards for California Public Schools, Grade 3: 4e; Grade 5: 3a-d, 4a-e; Grade 6: 4a-e; Grades 9-12, Earth Sciences: 5a-b)

Domain 3. Earth Resources

Candidates demonstrate an understanding of the Earth resources contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of Earth resources and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates know there are many different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable. They realize that sources of energy and materials differ in amounts, distribution, usefulness, and the time required for their formation. Candidates understand that the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process. They know the natural origin of the materials used to make common objects.

3.1 Earth Resources

a. Describe a variety of energy resources, including fossil fuels, nuclear fuels, solar, and biomass
b. Recognize earth materials as resources (e.g., rocks, minerals, soils, and water)
c. Identify resources as renewable vs. nonrenewable
d. Compare extraction and recycling in relation to energy, cost, and demand
e. Explain sustainable uses of resources with respect to utility, cost, human population, and environmental consequences

(Science Content Standards for California Public Schools, Grade 2: 3e; Grade 6: 6a-c; Grades 9-12, Earth Sciences: 9a, 9c)

Domain 4. Ecology

Candidates demonstrate an understanding of the foundations of the ecology contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of ecology and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand how organisms in ecosystems exchange energy and nutrients among themselves and with the environment. They can identify factors that affect organisms within an ecosystem, including natural hazards and human activity.

4.1 Ecology

a. Explain energy flow and nutrient cycling through ecosystems (e.g., food chain, food web)
b. Explain matter transfer (e.g., biogeochemical cycles) in ecosystems
c. Distinguish between abiotic and biotic factors in an ecosystem
d. Compare the roles of photosynthesis and respiration in an ecosystem
e. Describe interrelationships within and among ecosystems (e.g., predator/prey)
f. Identify and explain factors that affect population types and size (e.g., competition for resources, niche, habitats, species and population interactions, abiotic factors)

(Science Content Standards for California Public Schools, Grade 4: 2a-c, 3a-c; Grade 5: 2f-g; Grade 6: 5a-e)

Domain 5. Genetics and Evolution

Candidates demonstrate an understanding of the foundations of the genetics and evolution contained in the Science Content Standards for California Public Schools Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of genetics and evolution and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that a typical cell of any organism contains genetic instructions that specify its traits. They can explain how biological evolution accounts for the diversity of species that developed through gradual processes over many generations. Candidates can describe evidence used to explain the evolution of life on Earth.

5.1 Genetics and Evolution

a. Explain the inheritance of traits which are determined by one or more genes, including dominance, recessiveness, sex linkage, phenotypes, genotypes, and incomplete dominance
b. Solve problems that illustrate monohybrid and dihybrid crosses
c. Compare sexual and asexual reproduction
d. Explain how the coding of DNA (deoxyribonucleic acid) controls the expression of traits by genes
e. Define mutations and explain their causes
f. Explain the process of DNA replication
g. Describe evidence, past and present, that supports the theory of evolution, including diagramming relationships that demonstrate shared characteristics of fossil and living organisms
h. Explain the theory of natural selection, including adaptation, speciation, and extinction
i. List major events that affected the evolution of life on Earth (e.g., climate changes, asteroid impacts)

(Science Content Standards for California Public Schools, Grade 7: 2a-e, 3a-e; Grades 9-12, Biology/Life Sciences: 4c, 7c, 8a)

Domain 6. Molecular Biology and Biochemistry

Candidates demonstrate an understanding of the foundations of the molecular biology and biochemistry contained in the Science Content Standards for California Public Schools Kindergarten Through Grade Twelve (1998) (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of molecular biology and biochemistry and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand and apply the principles of chemistry that underlie the functioning of biological systems. They describe the properties of biochemical compounds that make them essential to life.

6.1 Biology and Biochemistry

a. Demonstrate understanding that a small subset of elements (C, H, O, N, P, S) makes up most of the chemical compounds in living organisms by combining in many ways
b. Recognize and differentiate the structure and function of molecules in living organisms, including carbohydrates, lipids, proteins, and nucleic acids
c. Describe the process of protein synthesis, including transcription and translation
d. Compare anaerobic and aerobic respiration
e. Describe the process of photosynthesis

(Science Content Standards for California Public Schools, Grade 5: 2f-g; Grade 6: 5a; Grade 8: 6b-c; Grades 9-12, Biology/Life Sciences: 1d, 1f, 1g, 1h, 4a, Chemistry: 10c)

Domain 7. Cell and Organismal Biology

Candidates demonstrate an understanding of the foundations of the cell and organismal biology contained in the Science Content Standards for California Public Schools Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of cell and organismal biology and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that all living organisms are composed of cells and explain important cellular processes. They describe and give examples of how the anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Candidates demonstrate understanding of physical principles that underlie biological structures and functions. They apply these principles to important biological systems.

7.1 Cell and Organismal Biology

a. Describe organelles and explain their function in the cell
b. Relate the structure of organelles and cells to their functions
c. Identify and contrast animal and plant cells
d. Explain the conversion, flow, and storage of energy of the cell
e. Identify the function and explain the importance of mitosis and meiosis as processes of cellular and organismal reproduction
f. Compare single-celled and multicellular organisms, noting the role of cell differentiation in the development of multicellular organisms
g. Describe the levels of organization (e.g., cells, tissues, organs, systems, organisms) in plants and animals
h. Describe the structures and functions of human body systems, including, but not limited to, the skeletal, reproductive, nervous, and circulatory systems
i. Explain the major structures and their functions in vascular and nonvascular plants
j. Describe the life processes of various plant groups, including, but not limited to, reproduction, photosynthesis, respiration, and transpiration
k. Explain the reproductive processes in flowering plants

(Science Content Standards for California Public Schools, Grade 3: 1b, 1c; Grade 5: 2a, 2e; Grade 7: 1a-f, 5a-g, 6d, 6h-j)

Domain 8. Waves

Candidates demonstrate an understanding of the foundations of waves as contained in the Science Content Standards for California Public Schools Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of waves and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that all waves have a common set of characteristic properties. They apply their knowledge of these properties to describe and predict the behavior of waves, including light waves, sound waves, and seismic waves. Candidates apply the simple principles of optics to explain how various lenses work.

8.1 Waves

a. Compare the characteristics of sound, light, and seismic waves (e.g., transverse/longitudinal, travel through various media, relative speed)
b. Explain that energy is transferred by waves without mass transfer and provide examples
c. Explain how lenses are used in simple optical systems, including the camera, telescope, microscope, and the eye
d. Explain and apply the laws of reflection and refraction
e. Compare transmission, reflection, and absorption of light in matter

(Science Content Standards for California Public Schools, Grade 3: 1d, 2a-d, 4c; Grade 6: 3a; Grade 7: 6a, 6c-g; Grades 9-12, Physics: 4a-b, 4d, 4f)

Domain 9. Forces and Motion

Candidates demonstrate an understanding of the foundations of forces and motion as contained in the Science Content Standards for California Public Schools Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of forces and motion and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates describe the motion of an object and understand the relationships among its velocity, speed, distance, time, and acceleration. They understand the relationship among force, mass, and acceleration. Candidates use Newton's laws to predict the motion of objects.

9.1 Forces and Motion

a. Discuss and apply Newton's laws (i.e., first, second, third, and law of universal gravitation)
b. Define pressure and relate it to fluid flow and buoyancy (e.g., heart valves, atmospheric pressure)
c. Describe the relationships among position, distance, displacement, speed, velocity, acceleration, and time, and perform simple calculations using these variables for both linear and circular motion
d. Identify the separate forces that act on a body (e.g., gravity, pressure, tension/compression, normal force, friction) and describe the net force on the body
e. Construct and analyze simple vector and graphical representations of motion and forces (e.g., distance, speed, time)
f. Identify fundamental forces, including gravity, nuclear forces, and electromagnetic forces (magnetic and electric), and explain their roles in nature, such as the role of gravity in maintaining the structure of the universe
g. Explain and calculate mechanical advantages for levers, pulleys, and inclined planes

(Science Content Standards for California Public Schools, Grade 7: 6h-j; Grade 8: 1a-f, 2a-g)

Domain 10. Electricity and Magnetism

Candidates demonstrate an understanding of the foundations of the electricity and magnetism contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of electricity and magnetism and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that electric and magnetic phenomena are related. They use knowledge of electricity and magnetism to explain many practical applications.

10.1 Electricity and Magnetism

a. Describe and provide examples of electrostatic and magnetostatic phenomena
b. Predict charges or poles based on attraction/repulsion observations
c. Build a simple compass and use it to determine direction of magnetic fields, including the Earth's magnetic field
d. Relate electric currents to magnetic fields and describe the application of these relationships, such as in electromagnets, electric current generators, motors, and transformers
e. Design and interpret simple series and parallel circuits
f. Define and calculate power, voltage differences, current, and resistance in simple circuits

(Science Content Standards for California Public Schools, Grade 4: 1a-g; Grade 9-12, Physics: 5a-c)

Domain 11. Heat Transfer and Thermodynamics

Candidates demonstrate an understanding of the foundations of heat transfer and thermodynamics as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of heat transfer and thermodynamics and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates explain how heat flows in a predictable manner. They understand that energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. Candidates apply their knowledge to explain how many phenomena on Earth's surface are affected by the transfer of energy through radiation and convection currents.

11.1 Heat Transfer and Thermodynamics

a. Know the principle of conservation of energy and apply it to energy transfers
b. Discuss how the transfer of energy as heat is related to changes in temperature
c. Diagram the direction of heat flow in a system
d. Describe the methods of heat transfer by conduction, convection, and radiation, and provide examples for each
e. Explain how chemical energy in fuel is transformed to heat
f. Design and explain experiments to induce a physical change such as freezing, melting, or boiling
g. Distinguish between physical and chemical changes and provide examples of each

(Science Content Standards for California Public Schools, Grade 6: 3a-d, 4d; Grade 8: 3b, 3d-e, 5c-d; Grade 9-12, Physics: 3a-c, Chemistry: 7a-c)

Domain 12. Structure and Properties of Matter

Candidates demonstrate an understanding of the structure and properties of matter contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of matter and its underlying structures, candidates have a deep conceptual knowledge of the content area. Candidates know that more than 100 elements of matter exist, each with distinct properties and a distinct atomic structure. They describe both macroscopic and microscopic properties of matter including intermolecular and intramolecular forces. They know that the organization of the periodic table is based on the properties of the elements and reflects the structure of atoms. Candidates understand how the periodic table is constructed and the periodic trends in chemical and physical properties that can be seen in the table. They recognize chemical reactions as processes that involve the rearrangement of electrons to break and form bonds with different atomic partners. Candidates demonstrate understanding of the principles of chemistry that underlie the functioning of biological systems.

12.1 Structure and Properties of Matter

a. Identify, describe, and diagram the basic components within an atom (i.e., proton, neutron, and electron)
b. Know that isotopes of any element have different numbers of neutrons but the same number of protons, and that some isotopes are radioactive
c. Differentiate between atoms, molecules, elements, and compounds
d. Compare and contrast states of matter and describe the role energy plays in the conversion from one state to another
e. Discuss the physical properties of matter including structure, melting point, boiling point, hardness, density, and conductivity
f. Recognize that all chemical substances are characterized by a unique set of physical properties
g. Define and calculate density, and predict whether an object will sink or float in a fluid
h. Explain that chemical changes in materials result in the formation of a new substance corresponding to the rearrangement of the atoms in molecules
i. Explain and apply principles of conservation of matter to chemical reactions, including balancing chemical equations
j. Distinguish among acidic, basic, and neutral solutions by their observable properties
k. Describe the construction and organization of the periodic table
l. Based on position in the periodic table, predict which elements have characteristics of metals, semi-metals, non-metals, and inert gases
m. Explain chemical reactivity using position on the periodic table
n. Predict and explain chemical bonding using elements' positions in the periodic table
o. Recognize that inorganic and organic compounds (e.g., water, salt, carbohydrates, lipids, proteins, nucleic acids) are essential to processes within living systems
p. Explain the central role of carbon in living system chemistry

(Science Content Standards for California Public Schools, Grade 8: 3a-c, 5a-e, 6a, 6c, 7a-c, 8a-d; Grades 9-12, Chemistry: 7b, 11c)

Biology/Life Science Subject Matter Requirements

Part I: Content Domains for Subject Matter Understanding and Skill in Biology/Life Science

Domain 1. Cell Biology and Physiology

Candidates demonstrate an understanding of the foundations of the cell biology and physiology contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of cell biology and physiology and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of the fundamental life processes of plants and animals that depend on a variety of chemical reactions that occur in specialized areas of an organism's cells. They recognize the coordination of organ systems and the relationship of structure to function. They use this understanding to apply the concepts of homeostasis and its mechanisms to the regulation of human body systems.

1.1 Prokaryotic and Eukaryotic Cells

a. Compare prokaryotic cells, eukaryotic cells, and viruses in terms of complexity, general structure, differentiation, and their requirements for growth and replication

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 1c, 1d)

1.2 Cellular Reproduction

a. Describe the stages of the cell cycle
b. Diagram and describe the stages of the mitotic process

(Science Content Standards for California Public Schools, Grades 7: 1e)

1.3 Plant and Animal Cell Anatomy and Physiology

a. Diagram the structure of the cell membrane and relate the structure to its function
b. Explain methods of transport across the membrane (e.g., diffusion, active transport, endocytosis and exocytosis)
c. Explain the role of semipermeable membranes in cellular communication
d. Explain the role of the endoplasmic reticulum and Golgi apparatus in the secretion of proteins
e. Explain the role of chloroplasts in obtaining and storing usable energy
f. Explain the role of mitochondria in cellular respiration

g. Explain the role of enzymes in chemical reactions and describe an experiment to test the catalytic role of enzymes and factors that affect enzyme activity (e.g., levels of protein organization, temperature, ionic conditions, concentration of enzyme and substrate, pH)
h. Explain anabolic and catabolic pathways involved in the metabolism of macromolecules (e.g., polysaccharides, nucleic acids, proteins, lipids)

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 1a-b, 1d-j)

1.4 Integration and Control of Human Organ Systems

a. Relate the complementary activity of major body systems (e.g., circulatory, digestive, respiratory, excretory) to provide cells with oxygen and nutrients and remove waste products
b. Explain and analyze the role of the nervous system in mediating communication between different parts of the body and the body's interactions with the environment
c. Explain the homeostatic role of the major organs (e.g., kidneys, heart, brain)
d. Explain the function of feedback loops in the nervous and endocrine systems to regulate conditions in the body and predict the effects of disturbances on these systems
e. Explain the role of hormones (e.g., digestive, reproductive, osmoregulatory) in providing internal feedback mechanisms for homeostasis at the cellular level and in whole organisms
f. Describe the role of the musculo-skeletal system in providing structure, support, and locomotion to the human organism

(Science Content Standards for California Public Schools, Grade 7: 5a-b; Grades 9-12, Biology/Life Sciences: 9a-i)

1.5 Physiology of the Immune System

a. Explain the humoral response to infection
b. Compare cell mediated and humoral responses to infection
c. Explain how vaccination works and distinguish among variables affecting success rate
d. Predict the consequences of a compromised immune system [e.g., AIDS (Acquired Immune Deficiency Syndrome)]

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 10b-f)

Domain 2. Genetics

Candidates demonstrate an understanding of the foundations of the genetics contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten

Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of genetics and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate understanding of the structure and function of genetic material. They understand the genetic coding of DNA (deoxyribonucleic acid) and how this coding specifies the sequence of amino acids in proteins characteristic of the organism. Candidates know that a multicellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization. They understand the roles of mutation and sexual reproduction in genetic variation within populations. They know how new biotechnology methods incorporate exogenous DNA into cells to alter their genetic composition, and the resulting ethical implications of using such methods. Candidates also understand the relationship of genetics to evolution and how the frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time.

2.1 Chromosome Structure and Function

a. Relate the structure and function of DNA, RNA (ribonucleic acid), and proteins to the concept of variation in organisms
b. Describe chromosome structure as a sequence of genes each with a specific locus

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 1d, 3d, 4a-c, 4e, 5a-b)

2.2 Patterns of Inheritance

a. Explain the necessity of both meiosis and fertilization in promoting variation
b. Describe the role of chromosomes in determining phenotypes (e.g., sex determination, chromosomal aberrations)
c. Predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance (e.g., autosomal or X-linked, dominant or recessive, co-dominance)
d. Explain the genetic and cellular bases for Mendel's laws of dominance, segregation and independent assortment

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 2a-g, 3b-c, 8a)

2.3 Gene Expression

a. Explain how random chromosome segregation explains the probability that a particular allele will be in a gamete
b. Recognize that specialization of cells in multicellular organisms is usually due to different patterns of gene expression rather than to differences among the genes themselves
c. Describe how alleles that are lethal in a homozygous individual may be carried in a heterozygote and thus maintained in a gene pool
d. Distinguish when and why mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in an encoded protein

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 3a, 4c-d, 7b-c)

2.4 Biotechnology

a. Recognize how genetic engineering (biotechnology) produces biomedical and agricultural products
b. Describe the construction of recombinant DNA molecules by basic DNA technology including restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 5c-e)

2.5 Bioethics

a. Discuss issues of bioethics including genetic engineering, cloning, the human genome project, gene therapy, and medical implications

(Science Content Standards for California Public Schools, Grades 9-12, Investigation and Experimentation:1m)

Domain 3. Evolution

Candidates demonstrate an understanding of the foundations of the evolution contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of evolution and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates explain that evolution is the result of genetic changes that occur in constantly changing environments. They know that the frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. Based on available evidence, they relate evolutionary theory to the history of life on Earth.

3.1 Natural Selection

a. Explain why natural selection acts on the phenotype rather than the genotype of an organism
b. Predict the survival potential of various groups of organisms based on the amount of diversity in their gene pools

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 7a-d)

3.2 Evolutionary Patterns

a. Analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction

b. Analyze the effects of evolutionary patterns on the diversity of organisms (e.g., genetic drift, convergent evolution, punctuated equilibrium, patterns of selection)
c. Explain the conditions for Hardy-Weinberg equilibrium and why they are unlikely to appear in nature, and solve equations to predict the frequency of genotypes in a population

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 7e-f, 8b-c, 8e)

3.3 Mechanisms for Speciation

a. Distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change
b. Describe a scenario that demonstrates the effects of reproductive or geographic isolation on speciation

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 6g, 8d)

3.4 History and Origin of Life

a. Explain the theoretical origins of life on Earth
b. Construct a branching diagram (cladogram) from a variety of data sources illustrating the phylogeny between organisms of currently identified taxonomic groups

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 8f-g)

Domain 4. Ecology

Candidates demonstrate an understanding of the foundations of the evolution contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of evolution and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate understanding that stability in an ecosystem is a balance among competing effects. They understand the interrelationships within ecosystems, the flow of matter and energy through ecosystems, and how humans impact the environment.

4.1 Biodiversity

a. Define biodiversity and describe the effects on biodiversity of alteration of habitat

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 6a-b)

4.2 Energy Flow and Nutrient Cycles

a. Evaluate the importance of stability of producers, consumers, and decomposers

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 6e-f)

4.3 Interrelationships and Change in Ecosystems

a. Describe various species interactions (e.g., predator/prey, parasitism, mutualism, commensalism, competition)
b. Analyze the fluctuations in population size in an ecosystem due to the relative rates of birth, immigration, emigration, and death
c. Analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, and changes in population size

(Science Content Standards for California Public Schools, Grades 9-12, Biology/Life Sciences: 6b-c)

Chemistry Subject Matter Requirements

Part I: Content Domains for Subject Matter Understanding and Skill in Chemistry

Domain 1. Atomic and Molecular Structure

Candidates demonstrate an understanding of atomic and molecular structure as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of atomic and molecular structure, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate understanding of how periodicity of physical and chemical properties of the elements relates to atomic structure. They base this on a demonstrated understanding of current models of atomic, molecular, and subatomic structure.

1.1 Periodic Table and Periodicity

a. Differentiate periodic groups and families of elements and their properties
b. Relate valence electrons and the electron shell structure (s, p, d, f orbitals) to an element's position in the periodic table
c. Predict periodic trends including electronegativity, ionization energy, and the relative sizes of ions and atoms

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1c-d, 1f-g)

1.2 Atomic Structure

a. Analyze the evolution of the atomic model (including, but not limited to, the historical importance of the Bohr model and the development of the quantum structure of the atom)
b. Relate atomic spectroscopy and the photoelectric effect to the quantum structure of the atom
c. Illustrate the position and describe the properties of quarks, protons, neutrons, and electrons within atoms

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: h-j, 11g)

1.3 Molecular Structure and Chemical Bonds

a. Compare types of molecular bonds including ionic, covalent and hydrogen bonds
b. Draw Lewis dot structures for compounds and ions
c. Predict molecular geometries using Lewis dot structures and hybridized atomic orbitals, e.g., valence shell electron pair repulsion model (VSEPR)
d. Relate intermolecular electrostatic forces, including Van der Waals, polar and induced polar, and ionic, to their expected states of matter and their characteristic physical properties

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 2a-h)

Domain 2. Chemical Reactions

Candidates demonstrate an understanding of the foundations of chemical reactions as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of chemical reactions and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of the principles that underlie the conditions governing chemical reactions. They apply the principle of conservation of matter and are able to quantify the mass of products and reactants. Candidates understand that chemical reaction rates depend on factors that affect the frequency of collisions and reactivities of reactant molecules. They explain and predict the behavior of chemical systems by applying the principle of chemical equilibrium as a dynamic process at the molecular level.

2.1 Conservation of Matter and Stoichiometry

a. Calculate molar mass, mass, number of particles, and volume, at standard temperature and pressure (STP) for elements and compounds
b. Calculate the masses of reactants and products, and percent yield using balanced chemical equations, including problems with a limiting reagent
c. Distinguish reaction types, including single replacement, double replacement, synthesis, decomposition, and combustion
d. Utilize the rules of oxidation states to balance oxidation-reduction reactions

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 3a-g)

2.2 Reaction Rates and Chemical Equilibrium

a. Predict the effect of temperature, pressure, and concentration on chemical equilibrium (LeChatelier's principle) and the reaction rate
b. Interpret a diagram showing activation energy along the reaction pathway
c. Identify and predict the role of catalysts on the reaction rate
d. Write and calculate an equilibrium constant expression for a given reaction

e. Know that equilibrium is established when the reaction rates of the forward and reverse reactions are equal

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 8a-d, 9a-c)

Domain 3. Kinetic Molecular Theory

Candidates demonstrate an understanding of the foundations of the kinetic molecular theory contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of kinetic molecular theory and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand kinetic molecular theory and use it to generate a description of the motion of atoms and molecules. They use kinetic molecular theory to explain and predict the properties and behaviors of gases.

3.1 Gases and Their Properties

a. Solve problems using the ideal gas law and use the ideal gas law to predict pressure-volume, pressure-temperature, and volume-temperature relationships
b. Relate pressure, volume, and temperature to the kinetic theory of atoms and molecules in gases
c. Know and use STP to solve gas law problems
d. Convert between Kelvin and Celsius temperature scales
e. Recognize the significance of absolute zero
f. Solve problems using Dalton's law of partial pressures and Graham's Laws of diffusion

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 4a-i)

Domain 4. Solution Chemistry

Candidates demonstrate an understanding of the foundations of the solution chemistry contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of solution chemistry and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates predict and explain the properties and behaviors of acids, bases, and salts in solution. They explain the properties of various solutions.

4.1 Solutions

a. Recognize and identify solutes and solvents
b. Calculate concentration in terms of molarity, parts per million, and percent composition
c. Describe the dissolving process at the molecular level
d. Explain how factors such as temperature, pressure, and surface area affect the dissolving process
e. Describe various methods for separation of solutions (e.g., chromatography, distillation)

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 6a-d, 6f)

4.2 Acids and Bases

a. Distinguish between strong and weak acids and bases based on degree of dissociation and their chemical properties
b. Calculate pH and hydrogen ion concentration in solutions including buffer solutions
c. Use Arrhenius, Brønsted-Lowry, and Lewis acid-base definitions appropriately to characterize acids and bases and in acid-base reactions

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 5a-g)

Domain 5. Chemical Thermodynamics

Candidates demonstrate an understanding of the foundations of the chemical thermodynamics contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of chemical thermodynamics and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate by solving problems an understanding that energy is exchanged or transformed in all chemical reactions and physical changes of matter. They apply the concepts of thermodynamic properties of materials such as specific heat, heats of fusion, heats of vaporization, and heat of reaction (enthalpy).

5.1 Chemical Thermodynamics

a. Perform calculations using specific heat, heats of fusion, heats of vaporization, and heat of reaction (enthalpy)
b. Interpret phase diagrams

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 7b, 7e)

Domain 6. Organic Chemistry and Biochemistry

Candidates demonstrate an understanding of the foundations of the organic chemistry and biochemistry contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of organic chemistry and biochemistry and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate understanding that the bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties, and provide the biochemical basis of life.

6.1 Organic Chemistry and Biochemistry

a. Explain the bonding characteristics of carbon
b. Recognize the chemical structure of various organic functional groups (i.e., alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids) and provide examples of reactions involving these groups
c. Inventory the ten simplest hydrocarbons that contain single bonds, multiple bonds, and benzene rings
d. Understand the differences in structures and properties between amino acids and their polymers and between sugars and their polymers

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 10b-f)

Domain 7. Nuclear Processes

Candidates demonstrate an understanding of the foundations of the nuclear processes contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of nuclear processes and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates explain nuclear processes including the radioactive decay of naturally occurring and human-made isotopes, nuclear fission, and nuclear fusion (e.g., stellar nucleosynthesis and synthesis of transuranium elements). They apply understanding of these processes to discuss the benefits and hazards of the use of radiation and radioactivity.

7.1 Nuclear Processes

a. Understand how mass-energy relationships in nuclear reactions and radioactive decay requires the relationship E=mc2
b. Compare and contrast alpha, beta, and gamma decay, and the relative kinds of damage to matter caused by α-, β-, and γ- rays
c. Perform calculations involving half-life
d. Contrast the benefits and hazards of the use of radiation and radioactivity

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11b, 11d-f; Investigation and Experimentation: 1m)

Earth and Planetary Science Subject Matter Requirements

Part I: Content Domains for Subject Matter Understanding and Skill in Earth and Planetary Science

Domain 1. Earth's Place in the Universe

Candidates demonstrate an understanding of Earth's place in the universe as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of the solar system and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand how Earth-based and space-based astronomy reveal the structure, scale, and changes in stars, galaxies, and the universe over time, and how astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. They base this understanding on their knowledge of the characteristics and properties of phenomena such as galaxies, stars, and bodies of the solar system.

1.1 Galaxies and Stars

a. Identify and describe characteristics of galaxies
b. Explain the evidence for the "big bang" model
c. Know that the Sun is a typical star and is powered by nuclear reactions, primarily the fusion of hydrogen to form helium
d. Describe the process of the nuclear synthesis of chemical elements and how accelerators simulate the conditions for nuclear synthesis (i.e., in stars and in the early universe)
e. Compare the use of visual, radio, and X-ray telescopes to collect data that reveal that stars differ in their life cycles
f. Describe, in terms of color and brightness, how the evolution of a star is determined by a balance between gravitational collapse and nuclear fusion

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 1e, 2b-g)

1.2 Solar Systems

a. Explain how the solar system was formed, including differences and similarities among the sun, terrestrial planets, and the gas planets, and cite the evidence from Earth and moon rocks that indicate that the solar system was formed approximately 4.6 billion years ago
b. Know the current evidence for the existence of planets orbiting other stars
c. Describe changes in the solar system over time

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 1a, 1b, 1g)

1.3 Planets and Satellites

a. Cite various forms of evidence that indicate the proximity of the planets in the solar system in relation to Earth and the stars
b. Cite various forms of evidence that Earth and other planets change over time
c. Describe the influence of collisional processes on early Earth and other planetary bodies in terms of shaping planetary surfaces and affecting life on Earth

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 1c, 1d, 1f)

Domain 2. Planet Earth

Candidates demonstrate an understanding of the foundations of Earth contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of Earth and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of the dynamic processes of the solid Earth, oceans, and the atmosphere. Candidates understand how plate tectonics operating over geologic time have changed the patterns of land, sea, and mountains on Earth's surface. Candidates also understand the dynamic processes that operate in and among the atmosphere, oceans and other water bodies, and the biosphere. They understand how life has changed Earth's atmosphere, and how changes in the atmosphere affect conditions for life. Candidates apply their knowledge of dynamic Earth processes to make predictions and form conclusions about surface phenomena such as earthquakes.

2.1 Tectonic Processes

a. Diagram the major divisions of the geologic time scale as a basis for understanding changes in the Earth's processes
b. Describe how earthquake intensity, magnitude, epicenter, focal mechanism, and distance are determined from a seismogram
c. Compare major types of volcanoes in terms of shape and chemical and rock composition
d. Describe the location and characteristics of volcanoes that are due to hot spots and those due to subduction
e. Relate geologic structures to tectonic settings and forces
f. Describe the evidence for plate tectonics on the sea floor and on land

(Science Content Standards for California Public Schools, Grade 7: 3c, 4b, 4d, 4g; Grades 9-12, Earth Sciences: 1c, 3a-b, 3d-f)

2.2 Oceans

a. Describe the chemical and physical properties of seawater
b. Describe the mechanisms that cause wave action and tides
c. Explain the layered structure of the oceans, including the generation of horizontal and vertical ocean currents and the geographic distribution of marine organisms, and how properties of ocean water, such as temperature and salinity, are related to these phenomena

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 5d)

2.3 Atmosphere

a. Compare the layers of the atmosphere in terms of chemical composition and thermal structure
b. Discuss the evolution of Earth's atmosphere over geologic time, including the effects of outgassing, the variations of carbon dioxide concentration, and the origin of atmospheric oxygen
c. Know the location of the ozone layer in the upper atmosphere, explain its role in absorbing ultraviolet radiation, and explain the way in which this layer varies both naturally and in response to human activities
d. Identify the bands at specific latitudes where rainforests and deserts are distributed and the causes of this pattern

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 5e-f, 8a-c)

Domain 3. Energy in the Earth System

Candidates demonstrate an understanding of energy in the Earth system contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of energy in the Earth system and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand how energy enters, flows through, and leaves the Earth system, and the relationship between energy transfer and the dynamic processes of the Earth system. They base this on knowledge of how energy enters the Earth system primarily as solar radiation and eventually escapes as heat, and how heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents. Candidates apply their knowledge of dynamic Earth processes to make predictions and form conclusions about surface phenomena such as climate.

3.1 Earth's Energy Budget: Inflow and Outflow

a. Compare the amount of incoming solar energy, the Earth's internal energy, the energy used by society, and the energy reflected back to space
b. Describe what happens to incoming solar radiation as it relates to reflection, absorption, and photosynthesis
c. Explain the mechanism and evaluate the significance of the greenhouse effect
d. Differentiate among greenhouse conditions on Earth, Mars, and Venus; the origins of those conditions; and the climatic consequences of each

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 4a-d, 6a)

3.2 Circulation in the Oceans and Atmosphere

a. Assess the differential effects of heating on circulation patterns in the atmosphere and oceans
b. Relate the rotation of Earth to the circular motions of ocean currents and air in low- and high-pressure centers
c. Compare the causes and structures of various cloud types, precipitation, air masses, and fronts, and the causes and effects of different types of severe weather
d. Know and explain features of the ENSO cycle (El Niño southern oscillation, including La Niña) in terms of sea-surface and air temperature variations across the Pacific, and climatic results of this cycle

(Science Content Standards for California Public Schools, Grade 5: 3b-c, 4c; Grades 9-12, Earth Sciences: 5a-b, 5g)

3.3 Climate Variations in Time and Space

a. Analyze weather (short-term) and climate (over time) in relation to the transfer of energy into and out of the atmosphere
b. Discuss and assess factors that affect climate including latitude, elevation, topography, and proximity to large bodies of water and cold or warm ocean currents

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 5e, 6a, 6b)

Domain 4. Biogeochemical Cycles

Candidates demonstrate an understanding of the foundations of the biogeochemical cycles contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of biogeochemical cycles and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of how each element on Earth moves among reservoirs, which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles. Candidates

understand how the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.

4.1 Rock Cycle

a. Compare and contrast the properties of rocks based on physical and chemical conditions in which rocks are formed, including plate tectonic processes
b. Identify common rock-forming minerals (e.g., feldspars, quartz, biotite, calcite) using a table of diagnostic properties
c. Identify common ore minerals as sources of copper, iron, lead, zinc, cement, halite, gypsum, and uranium

(Science Content Standards for California Public Schools, Grade 4: 4b, 6c; Grades 9-12, Earth Sciences: 3c)

4.2 Water, Carbon, and Nitrogen Cycles

a. Illustrate the mechanism that drives the water cycle
b. Compare the processes of photosynthesis and respiration in terms of reservoirs of carbon and oxygen
c. Identify the carbon reservoirs (i.e., physical and chemical forms of carbon in the atmosphere, oceans, biomass, soils, fossil fuels, and solid earth) and describe the movement of carbon among these reservoirs in the global carbon cycle
d. Describe the nitrogen cycle as it relates to the atmosphere, soils as reservoirs, life processes, and pollution

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 7a-d)

Domain 5. California Geology

Candidates demonstrate an understanding of the foundations of the California geology contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of California geology and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that the geology of California underlies the state's scenic diversity and wealth of natural resources as well as its natural hazards. Candidates are familiar with the geology of California, and are aware of the unique opportunities for field experiences in the state. Candidates describe activities using geologic maps that illustrate processes, location, and scale of phenomena. Candidates also describe field experiences that include the basic elements of geologic mapping to record and interpret the history of geological processes portrayed in California.

5.1 Tectonic Evolution

a. Interpret geologic maps as a basis for understanding the tectonic evolution of California in terms of plate margins (i.e., Atlantic-type passive margin, Japanese volcanic arc, Andean arc, and faulted margin)

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 9d, Investigation and Experimentation: 1h)

5.2 Major Economic Earth Resources

a. Understand the importance of water to society, the origins of California's fresh water, statewide water distribution, and the environmental and economic impact of water re-distribution
b. Describe resources of major economic importance in California and their relation to California's geology (e.g., oil, gas, gold, sand, gravel, salts, open space, soil, arable land, clean air)

(Science Content Standards for California Public Schools, Grade 6: 6b; Grades 9-12, Earth Sciences: 9a, 9c)

5.3 Surface Processes

a. Assess mechanisms by which tectonics, geologic structures (i.e., folds and faults), and rock properties influence surface properties (e.g., flow of water, differential erosion, uplift, subsidence)
b. Discuss the factors controlling the influence of water in modifying the landscape
c. Interpret the factors controlling erosion, deposition, and transport in surficial processes
d. Appraise desert environments in terms of water resource needs for habitation

(Science Content Standards for California Public Schools, Grade 4: 5b-c; Grade 6: 2a-c)

5.4 Natural Hazards

a. Analyze published geologic hazard maps of California and know how to use maps to identify evidence of geologic events of the past and to predict the likelihood of geologic changes in the future

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 9b, 9d, Investigation and Experimentation: 1h)

5.5 Geologic Mapping

a. Know how to find position using a topographic map
b. Know how to make a geologic map showing faults, structural data, and contacts between formations
c. Know how to interpret geologic history and processes from a geologic map

(Science Content Standards for California Public Schools, Grade 6: 7f; Grades 9-12: Earth Sciences, 9d;Investigation and Experimentation; 1h)

Physics Subject Matter Requirements

Part I: Content Domains for Subject Matter Understanding and Skill in Physics

Domain 1. Motion and Forces

Candidates demonstrate an understanding of the foundations of motion and forces as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of motion and forces and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of motion and the relationship of force to motion. Candidates use analytical, numerical, and graphical methods in problem-solving.

1.1 Motion and Forces

a. Solve problems using Newton's Second Law (e.g., problems involving time, velocity, and space-dependent forces)
b. Construct appropriate free-body diagrams of many-body problems (e.g., two or more coupled masses)
c. Solve periodic motion problems
d. Solve 2-dimensional problems involving vector analysis of motion and forces, including projectile motion, uniform circular motion, and statics
e. Generate and understand functional relationships of graphs showing distance, velocity, and acceleration versus time
f. Recognize relationships among variables for linear motion and rotational motion
g. Solve problems involving linear and rotational motion in term of forces and torques

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 1a-m)

Domain 2. Conservation of Energy and Momentum

Candidates demonstrate an understanding of the conservation of energy and momentum contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of conservation of energy and momentum and of their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of the principles of conservation of energy and momentum. They apply this understanding to predict and describe the movement of objects.

2.1 Conservation of Energy and Momentum

a. Use conservation of energy to characterize kinetic-potential energy systems such as oscillating systems (pendula and springs), projectile motion, and roller coasters
b. Analyze elastic and inelastic collisions and solve for unknown values
c. Solve problems involving linear and rotational motion in terms of conservation of momentum and energy
d. Recognize relationships between energy/momentum conservation principles and Newton's Laws
e. Examine the impact of friction on conservation principles
f. Interpret force-versus-time and force-versus-distance graphs to find, for example, work done or impulse on a system

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 2a-h)

Domain 3. Heat and Thermodynamics

Candidates demonstrate an understanding of the foundations of heat and thermodynamics as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of heat and thermodynamics and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate understanding of the laws of thermodynamics and the thermodynamic properties of materials.

3.1 Heat and Thermodynamics

a. Solve problems involving the laws of thermodynamics using the relationships among work, heat flow, energy, and entropy
b. Define and correctly apply thermodynamic properties of materials such as specific heat (heat capacity), heats of fusion, heat of vaporization, thermal conductivity, and thermal expansion to solve problems
c. Solve problems for ideal gas systems
d. Solve problems involving cyclic processes, including calculations of work done, heat gain/loss, , and entropy change
e. Interpret graphs showing phase changes and graphs of cyclic processes
f. Describe a plasma, state its characteristic properties, and contrast it with an ideal gas

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 3a-g)

Domain 4. Waves

Candidates demonstrate an understanding of the foundations of waves as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of waves and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates can describe waves and their characteristic properties and understand that these properties do not depend on the type of wave. They use their knowledge of waves and wave properties to predict wave behavior under various conditions. Candidates are familiar with the electromagnetic spectrum.

4.1 Waves and Their Characteristic Properties

a. Relate wave propagation to properties of materials (e.g., predict wave speed from density and tension)
b. Describe, distinguish, and solve both conceptual and numerical problems involving interference, diffraction, refraction, reflection, Doppler effect, polarization, dispersion, and scattering

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 4a-f)

Domain 5. Electromagnetism

Candidates demonstrate an understanding of the foundations of electromagnetism contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of electromagnetism and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand the relationship between electric and magnetic phenomena and can apply their knowledge to real-life examples. They can solve calculus-based problems using the quantitative and vector relationships among charges, currents, forces, and fields.

5.1 Electric and Magnetic Phenomena

a. Analyze electric and magnetic forces, charges, and fields using Coulomb's law, the Lorentz force, and the right-hand rule
b. Apply energy principles to analyze problems in electricity, magnetism, and circuit theory involving capacitors, resistors, and inductors
c. Calculate power, voltage changes, current, and resistance in multiloop circuits involving capacitors, resistors, and inductors
d. Interpret and design mixed series and parallel circuits involving capacitors, resistors, and inductors

e. Solve problems involving the relationships between electric and magnetic phenomena
f. Explain properties of transistors, diodes, and semiconductors

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 5a-o)

Domain 6. Quantum Mechanics and the Standard Model of Particles

Candidates demonstrate an understanding of the foundations of quantum mechanics and the standard model of particles contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of quantum mechanics and the standard model of particles and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates are familiar with the standard model of particles and the four fundamental forces of nature. They recognize the assumptions and principles of early quantum mechanics.

6.1 Quantum Mechanics and the Standard Model

a. Distinguish the four fundamental forces of nature, describe their ranges, and identify their force carriers
b. Evaluate the assumptions and relevance of the Bohr model of the atom

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1i)

Part II: Subject Matter Skills and Abilities Applicable to the Content Domains in Science

Domain 1. Investigation and Experimentation

Candidates for Single Subject Teaching Credentials in Science formulate and conduct scientific investigations. They select appropriate scientific tools, make relevant measurements of changes in natural phenomena, and present unbiased findings in logical and meaningful formats using charts, maps, tables, models, graphs, and labeled diagrams. Candidates apply mathematics to scientific investigations and experimentation(s) for the purpose of quantifying results and drawing conclusions. Candidates interpret experimental results and determine whether further information is necessary to formulate accurate conclusions. They communicate results through various methods, and use technology where appropriate.

1.1 Question Formulation

a. Formulate and evaluate a viable hypothesis
b. Recognize the value and role of observation prior to question formulation
c. Recognize the iterative nature of questioning
d. Given an experimental design, identify possible hypotheses that it may test

(Science Content Standards for California Public Schools, Grade 6: 7a)

1.2 Planning a Scientific Investigation (including Experimental Design)

a. Given a hypothesis, formulate an investigation or experimental design to test that hypothesis
b. Evaluate an experimental design for its suitability to test a given hypothesis
c. Distinguish between variable and controlled parameters

(Science Content Standards for California Public Schools, Grade 5: 6c-d; Grade 8: 9a, 9c)

1.3 Observation and Data Collection

a. Identify changes in natural phenomena over time without manipulating the phenomena (e.g., a tree limb, a grove of trees, a stream, a hill slope)
b. Analyze the locations, sequences, and time intervals that are characteristic of natural phenomena (e.g., locations of planets over time, succession of species in an ecosystem)
c. Select and use appropriate tools and technology (e.g., computer-linked probes, spreadsheets, graphing calculators) to perform tests, collect data, analyze relationships, and display data
d. Evaluate the precision, accuracy, and reproducibility of data
e. Identify and analyze possible reasons for inconsistent results, such as sources of error or uncontrolled conditions
f. Identify and communicate sources of unavoidable experimental error

g. Recognize the issues of statistical variability and explain the need for controlled tests
h. Know and evaluate the safety issues when designing an experiment and implement appropriate solutions to safety problems
i. Appropriately employ a variety of print and electronic resources (e.g., the World Wide Web) to collect information and evidence as part of a research project
j. Assess the accuracy validity and reliability of information gathered from a variety of sources

(Science Content Standards for California Public Schools, Grade 3: 5a; Grade 6: 7a-b, 7g-h; Grade 7: 7a-b; Grade 8: 9b; Grades 9-12, Investigation and Experimentation: 1a-c, 1i-j, 1m)

1.4 Data Analysis/Graphing

a. Construct appropriate graphs from data and develop qualitative and quantitative statements about relationships between variables
b. Recognize the slope of the linear graph as the constant in the relationship y=kx and apply this principle in interpreting graphs constructed from data
c. Apply simple mathematical relationships to determine a missing quantity in an algebraic expression, given the two remaining terms (e.g., speed = distance/time, density = mass/volume, force = pressure x area, volume = area x height)
d. Determine whether a relationship on a given graph is linear or non-linear and determine the appropriateness of extrapolating the data
e. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions

(Science Content Standards for California Public Schools, Grade 6: 7c; Grade 8: 9d-g; Grades 9-12, Investigation and Experimentation: 1e)

1.5 Drawing Conclusions and Communicating Explanations

a. Draw appropriate and logical conclusions from data
b. Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence
c. Communicate the steps and results of an investigation in written reports and oral presentations
d. Recognize whether evidence is consistent with a proposed explanation
e. Construct appropriate visual representations of scientific phenomenon and processes (e.g., motion of Earth's plates, cell structure)
f. Read topographic and geologic maps for evidence provided on the maps and construct and interpret a simple scale map

(Science Content Standards for California Public Schools, Grade 5: 6g; Grade 6: 7e-f; Grade 7: 7c-e; Grade 8: 9a; Grades 9-12, Investigation and Experimentation: 1d, 1h)

Domain 2. Nature of Science

Candidates recognize that science is an active endeavor in which acquisition of knowledge is based upon the collection and examination of data. Candidates understand that scientists have a responsibility to report fully and openly the methods and results of their observations and experiments, even if those results disagree with their favored hypotheses or are controversial in public opinion. They understand that to hide data, arbitrarily eliminate data, or conceal how an experiment was conducted is to invite errors, make those errors difficult to discover, and risk harm to colleagues and communities. They understand that scientists carefully consider questions and challenges raised by fellow scientists about the assumptions, procedures, and accuracy of their experiments. They understand that a fundamental aspect of scientific inquiry is that it is dynamic and self-correcting by design. Conclusions, hypotheses, and theories are tested in every experiment and revised or rejected when they no longer correctly or accurately predict experimental results. Candidates understand that scientists must consider the safety, ethical concerns, risks, and costs and benefits of experiments to society.

2.1 Scientific Inquiry

a. Distinguish among the terms hypothesis, theory, and prediction as used in scientific investigations
b. Evaluate the usefulness, limitations, and interdisciplinary and cumulative nature of scientific evidence as it relates to the development of models and theories as representations of reality
c. Recognize that when observations do not agree with an accepted scientific theory, either the observations are mistaken or fraudulent, or the accepted theory is erroneous or incorrect
d. Understand that reproducibility of data is critical to the scientific endeavor
e. Recognize that science is a self-correcting process that eventually identifies misconceptions and experimental biases
h. Recognize that an inquiring mind is at the heart of the scientific method and that doing science involves thinking critically about the evidence presented, the usefulness of models, and the limitations of theories
i. Recognize that theories are judged by how well they explain observations and predict results and that when they represent new ideas that are counter to mainstream ideas they often encounter vigorous criticism
j. Recognize that when observations, data, or experimental results do not agree, the unexpected results are not necessarily mistakes; to discard the unusual in order to reach the expected is to guarantee that nothing but what is expected will ever be seen
k. Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out

(Science Content Standards for California Public Schools, Grade 6: 7e; Grades 9-12, Investigation and Experimentation: 1f-g, 1n)

2.2 Scientific Ethics

a. Understand that honesty is at the core of scientific ethics; first and foremost is the honest and accurate reporting of procedures used and data collected
b. Know that all scientists are obligated to evaluate the safety of an investigation and ensure the safety of those performing the experiment
c. Know the procedures for respectful treatment of all living organisms in experimentation and other investigations

2.3 Historical Perspectives

a. Discuss the cumulative nature of scientific evidence as it relates to the development of models and theories
b. Recognize that as knowledge in science evolves, when observations do not support an accepted scientific theory, the observations are reconsidered to determine if they are mistaken or fraudulent, or if the accepted theory is erroneous or incomplete (e.g., an erroneous theory is the Piltdown Man fossil; an incomplete theory is Newton's laws of gravity)
c. Recognize and provide specific examples that scientific advances sometimes result in profound paradigm shifts in scientific theories
d. Discuss the need for clear and understandable communication of scientific endeavors so that they may be reproduced and why reproduction of these endeavors is important

(Science Content Standards for California Public Schools, Grade 6: 7d; Grade 7: 7c, 7e; Grades 9-12, Investigation and Experimentation: 1k, 1n)

Domain 3. Science and Society

Candidates understand that science relies on basic human qualities such as reasoning, insight, curiosity, skill, and creativity – as well as on scientific habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. Candidates recognize their responsibility to increase scientific literacy so that the general population can understand current issues and appreciate their personal roles and responsibilities. Candidates know about possible hazards and take precautions that are the basis for creating a safe learning environment that benefits all students. They are familiar with established rules and guidelines that intend to ensure the safety of students and to protect the subjects and environments studied. Candidates understand that technology is the application of proven scientific knowledge for practical purposes serving human needs; however, science and technology are interrelated—one often propels the other.

3.1 Science Literacy

a. Recognize that science attempts to make sense of how the natural and the designed world function
b. Demonstrate the ability to apply critical and independent thinking to weigh alternative explanations of events
c. Apply evidence, numbers, patterns, and logical arguments to solve problems

d. Understand that, although much has been learned about the objects, events and phenomena in nature, there are many unanswered questions, i.e., science is a work in progress
e. Know that the ability of science and technology to resolve societal problems depends on the scientific literacy of a society

3.2 Diversity

a. Identify examples of women and men of various social and ethnic backgrounds with diverse interests, talents, qualities and motivations who are, or who have been, engaged in activities of science and related fields

3.3 Science, Technology, and Society

a. Identify and evaluate the impact of scientific advances on society
b. Recognize that scientific advances may challenge individuals to reevaluate their personal beliefs

(Science Content Standards for California Public Schools, Grades 9-12, Investigation and Experimentation: 1m, 1n)

3.4 Safety

a. Choose appropriate safety equipment for a given activity (e.g., goggles, apron, vented hood)
b. Discuss the safe use, storage, and disposal of commonly used chemicals and biological specimens
c. Assess the safety conditions needed to maintain a science laboratory (e.g., eye wash, shower, fire extinguisher)
d. Read and decode MSDS/OSHA (Material Safety Data Sheet/Occupational Safety and Health Administration) labels on laboratory supplies and equipment
e. Discuss key issues in the disposal of hazardous materials in either the laboratory or the local community
f. Be familiar with standard safety procedures such as those outlined in the Science Safety Handbook for California Schools (1999)

Appendix A
Assembly Bill No. 537

CHAPTER 587

An act to amend Sections 200, 220, 66251, and 66270 of, to add Section 241 to, and to amend and renumber Sections 221 and 66271 of, the Education Code, relating to discrimination.

[Approved by Governor October 2, 1999. Filed
with Secretary of State October 10, 1999.]

LEGISLATIVE COUNSEL'S DIGEST

AB 537, Kuehl. Discrimination.

(1) Existing law provides that it is the policy of the State of California to afford all persons in public schools and postsecondary institutions, regardless of their sex, ethnic group identification, race, national origin, religion, or mental or physical disability, equal rights and opportunities in the educational institutions of the state.

Existing law makes it a crime for a person, whether or not acting under color of law, to willfully injure, intimidate, interfere with, oppress, or threaten any other person, by force or threat of force, in the free exercise or enjoyment of any right or privilege secured to him or her by the Constitution or laws of this state or by the Constitution or laws of the United States because of the other person's race, color, religion, ancestry, national origin, disability, gender, or sexual orientation, or because he or she perceives that the other person has one or more of those characteristics.

This bill would also provide that it is the policy of the state to afford all persons in public school and postsecondary institutions equal rights and opportunities in the educational institutions of the state, regardless of any basis referred to in the aforementioned paragraph.

(2) Existing law prohibits a person from being subjected to discrimination on the basis of sex, ethnic group identification, race, national origin, religion, color, or mental or physical disability in any program or activity conducted by any educational institution or postsecondary educational institution that receives, or benefits from, state financial assistance or enrolls students who receive state student financial aid.

This bill would also prohibit a person from being subjected to discrimination on the basis of any basis referred to in paragraph (1) in any program or activity conducted by any educational institution or postsecondary educational institution that receives, or benefits from, state financial assistance or enrolls students who receive state student financial aid.

(3) This bill would state that it does not require the inclusion of any curriculum, textbook, presentation, or other material in any program or activity conducted by an educational institution or a postsecondary educational institution and would prohibit this bill from being deemed to be violated by the omission of any curriculum, textbook, presentation, or other material in any program or activity conducted by an educational institution or a postsecondary educational institution.

To the extent that this bill would impose new duties on school districts and community college districts, it would impose a state-mandated local program.

(4) The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement, including the creation of a State Mandates Claims Fund to pay the costs of mandates that do not exceed $1,000,000 statewide and other procedures for claims whose statewide costs exceed $1,000,000.

This bill would provide that, if the Commission on State Mandates determines that the bill contains costs mandated by the state, reimbursement for those costs shall be made pursuant to these statutory provisions.

The people of the State of California do enact as follows:

SECTION 1. This bill shall be known, and may be cited, as the California Student Safety and Violence Prevention Act of 2000.

SEC. 2. (a) The Legislature finds and declares all of the following:

(1) Under the California Constitution, all students of public schools have the inalienable right to attend campuses that are safe, secure, and peaceful. Violence is the number one cause of death for young people in California and has become a public health problem of epidemic proportion. One of the Legislature's highest priorities must be to prevent our children from the plague of violence.

(2) The fastest growing, violent crime in California is hate crime, and it is incumbent upon us to ensure that all students attending public school in California are protected from potentially violent discrimination. Educators see how violence affects youth every day; they know first hand that youth cannot learn if they are concerned about their safety. This legislation is designed to protect the institution of learning as well as our students.

(3) Not only do we need to address the issue of school violence but also we must strive to reverse the increase in teen suicide. The number of teens who attempt suicide, as well as the number who actually kill themselves, has risen substantially in recent years. Teen suicides in the United States have doubled in number since 1960 and every year over a quarter of a million adolescents in the United States attempt suicide. Sadly, approximately 4,000 of these attempts every year are completed. Suicide is the third leading cause of death for youths 15 through 24 years of age. To combat this problem we must seriously examine these grim statistics and take immediate action to ensure all students are offered equal protection from discrimination under California law.

SEC. 3. Section 200 of the Education Code is amended to read:

200. It is the policy of the State of California to afford all persons in public schools, regardless of their sex, ethnic group identification, race, national origin, religion, mental or physical disability, or regardless of any basis that is contained in the prohibition of hate crimes set forth in subdivision (a) of Section 422.6 of the Penal Code, equal rights and opportunities in the educational institutions of the state. The purpose of this chapter is to prohibit acts which are contrary to that policy and to provide remedies therefor.

SEC. 4. Section 220 of the Education Code is amended to read:

220. No person shall be subjected to discrimination on the basis of sex, ethnic group identification, race, national origin, religion, color, mental or physical disability, or any basis that is contained in the prohibition of hate crimes set forth in subdivision (a) of Section 422.6 of the Penal Code in any program or activity conducted by an educational institution that receives, or benefits from, state financial assistance or enrolls pupils who receive state student financial aid.

SEC. 5. Section 221 of the Education Code is renumbered to read:

220.5. This article shall not apply to an educational institution which is controlled by a religious organization if the application would not be consistent with the religious tenets of that organization.

SEC. 6. Section 241 is added to the Education Code, to read:

241. Nothing in the California Student Safety and Violence Prevention Act of 2000 requires the inclusion of any curriculum, textbook, presentation, or other material in any program or activity conducted by an educational institution or postsecondary educational institution; the California Student Safety and Violence Prevention Act of 2000 shall not be deemed to be violated by the omission of any curriculum, textbook, presentation, or other material in any program or activity conducted by an educational institution or postsecondary educational institution.

SEC. 7. Section 66251 of the Education Code is amended to read:

66251. It is the policy of the State of California to afford all persons, regardless of their sex, ethnic group identification, race, national origin, religion, mental or physical disability, or regardless of any basis that is contained in the prohibition of hate crimes set forth in subdivision (a) of Section 422.6 of the Penal Code, equal rights and opportunities in the postsecondary institutions of the state. The purpose of this chapter is to prohibit acts that are contrary to that policy and to provide remedies therefor.

SEC. 8. Section 66270 of the Education Code is amended to read:

66270. No person shall be subjected to discrimination on the basis of sex, ethnic group identification, race, national origin, religion, color, or mental or physical disability, or any basis that is contained in the prohibition of hate crimes set forth in subdivision (a) of Section 422.6 of the Penal Code in any program or activity conducted by any postsecondary educational institution that receives, or benefits from, state financial assistance or enrolls students who receive state student financial aid.

SEC. 9. Section 66271 of the Education Code is renumbered to read:

66270.5. This chapter shall not apply to an educational institution that is controlled by a religious organization if the application would not be consistent with the religious tenets of that organization.

SEC. 10. Notwithstanding Section 17610 of the Government Code, if the Commission on State Mandates determines that this act contains costs mandated by the state, reimbursement to local agencies and school districts for those costs shall be made pursuant to Part 7 (commencing with Section 17500) of Division 4 of Title 2 of the Government Code. If the statewide cost of the claim for reimbursement does not exceed one million dollars ($1,000,000), reimbursement shall be made from the State Mandates Claims Fund.